

Hot Topics in the NASA Workmanship Standards Program

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Quality Leadership Forum

March 2013



Office of Safety and Mission Assurance



Agenda

- Standard of Standards
 - ❖ *Training*
- Printed Circuit Boards
- Soldering
- Cables and Harnesses
- Polymeric Applications
- ESD Control



Standards of Standards

- NASA-STD-8739.6, Implementation Requirements for NASA Workmanship Standards
- Published September 5, 2012
- Fill requirements gap between VCS and NASA needs
- Covers global requirements which apply to all Workmanship standards: applicability, visual acuity, facility temperature and humidity, training
- Codify Training Center policies



JPL's Mid-Infrared Instrument (MIRI) for JWST



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Example 1: Applicability to COTS

“1.2.3 The workmanship requirements of this document do not apply to suppliers of commercial-off-the-shelf (COTS) items. Projects which use COTS hardware for applications described in 1.2.2 above are responsible for identifying and managing risk associated with hardware that was built without material controls, production methods, and/or quality inspections defined by the workmanship standards.”

- ⌘ COTS suppliers are retailers, not contractors building to spec.
- ⌘ Performance and reliability must be assured. (per Mission Risk Classification)
- ⌘ Standard, proven, low-cost assurance methods may not be available for printed wiring assembly (PWA) and cable harness assembly quality assurance.
- ⌘ Custom assurance methods must address relevant defect types and failure modes. *For low-risk missions overall cost may be higher.*

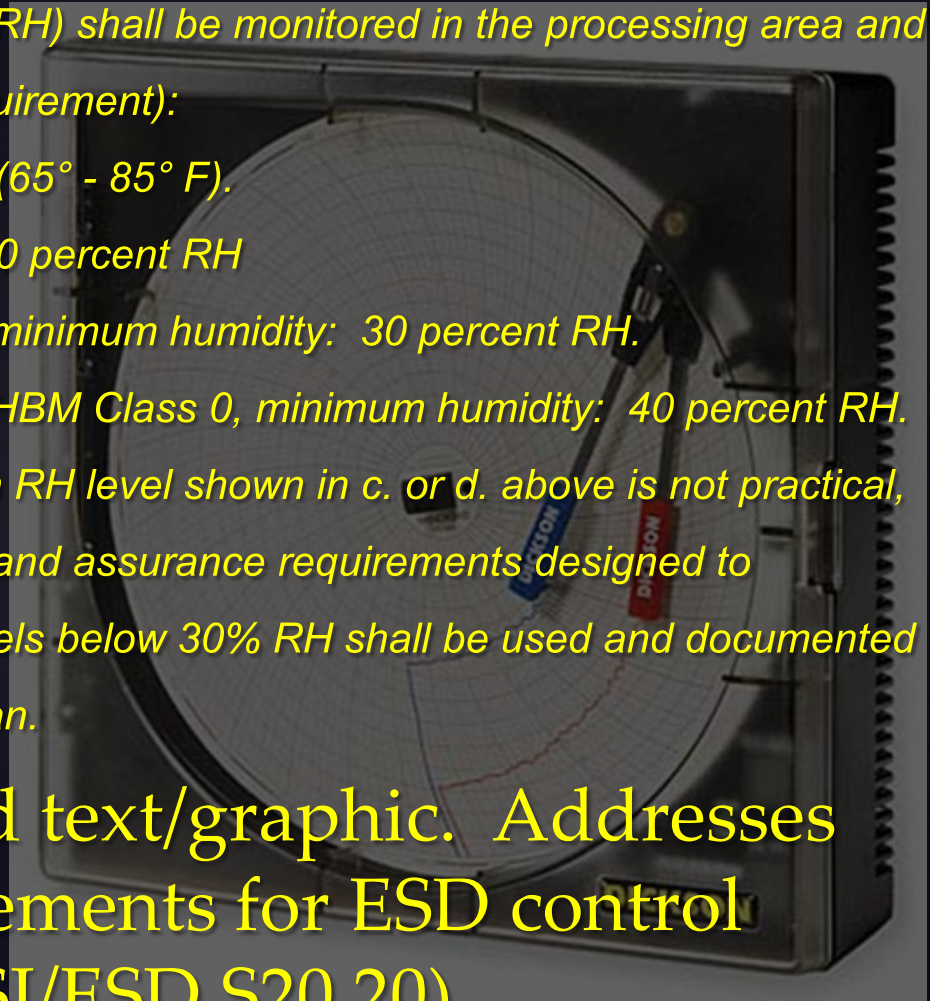
Example 2: Lab Operating Conditions

6.1.1 Temperature and relative humidity (RH) shall be monitored in the processing area and maintained within the following limits (Requirement):

- a) For temperature: 18° - 30° C (65° - 85° F).*
- b) Maximum relative humidity: 70 percent RH*
- c) For ESD-sensitive hardware, minimum humidity: 30 percent RH.*
- d) For ESD-sensitive hardware, HBM Class 0, minimum humidity: 40 percent RH.*

6.1.2 For instances where maintaining an RH level shown in c. or d. above is not practical, special methods, procedures, equipment, and assurance requirements designed to overcome the risks of relative humidity levels below 30% RH shall be used and documented in the applicable ESD Control Program Plan.

Fixes confusion with old text/graphic. Addresses lack of humidity requirements for ESD control during operations (ANSI/ESD S20.20).



Standards of Standards – Training Policy

Extensive Appendix on Training. Important policies on:

- NASA Level B Training Centers: JSC, MSFC
 - Can train any operator or inspector (not Level B instructor): industry, NASA, DCMA, etc.
- NASA personnel certification:
 - Training is part of certification
 - Personnel do not self-certify
 - Trainers do not certify
 - NASA certification is more than IPC certification
 - NASA certification is not portable
 - Supervisor is accountable for personnel's certification status



Standards of Standards – Training Policy

- Consistent use of training variations: Initial, Retraining, Partial, On-line.
- Consistent use of curricula and grading
- Solidified 3-month grace period. Training credentials valid for 27 months. Certification still needs to be renewed after 24 months.
- Shorter retraining class shall be offered if within 27 month window, regardless of prior school. After 27 months, school determines class that can be taken.



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Standards of Standards – Training Policy

- Treating NASA instruction of Workmanship courses as ITAR. Technical Assistance Agreement (TAA) required for foreign nationals.
- Policy for certifying Level A Instructors:
 - How to stay current?
 - How to share lessons learned?
 - How to encourage unified training product?
- How to include 8739.6 content in training classes?



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Overview of the RITF

Receiving, Inspection and Test Facility

Founded in 1989, the RITF is a critical support facility at NASA Johnson Space Center in the Safety and Mission Assurance Directorate.

The RITF is operated for NASA by SAIC and provides testing and evaluation, screening services, and training to the technical community.

The RITF has established control programs for Electrostatic Discharge (ESD) and Counterfeit Parts Avoidance.

The RITF is a AS9100-registered laboratory and holds an ISO/IEC17025 accreditation.

Testing and Evaluation

- Chemical analysis
- Environmental testing
- Failure analysis
- Mechanical testing
- Metallographic analysis
- Radiographic analysis

Screening Services

- Counterfeit parts identification
- Electronic component screening
- Fastener acceptance screening
- FOD and loose particle screening
- Wire and cable acceptance screening

Training

- The RITF is a NASA Level B Workmanship Standards Training Center.

Course List

Available Workmanship Training Courses	
Course	Duration (hours)
Through-hole Soldering	40
Cable, Harness & Crimp Training/Inspection	40
Conformal Coating & Staking Training/Inspection	24
Electrostatic Discharge Control - Levels 1, 2, 3 [i/a/w JSC's Control Plan]	4 per level
Surface Mount Soldering Training/Inspection	40
Fiber Optic Terminations Training	24
Lithium Battery Handling Familiarization	2
Wire Wrapping	8
NASA Workmanship Standards Familiarization	8
Requirement for Soldered Electrical and Electronic Assemblies (IPC J-STD-001 ES)	40

Shorter versions of most courses are available for retraining

Contact Information

NASA Johnson Space Center

RITF: B15/R2001

2101 NASA Parkway

Houston, Texas 77058

<http://ritf-sma.jsc.nasa.gov/Resources.html>

www.nasa.gov/centers/johnson/ritf/

NASA Point of Contact:

Cheryl Corbin

JSC Safety and Mission Assurance
Directorate

cheryl.a.corbin@nasa.gov

281-244-8423

BayTech Point of Contact:

Kim Morris

832-536-3260

kim@bayareahouston.com

Via a Space Act Agreement with Bay Area Houston Advanced Technology Consortium (BayTech), organizations can establish a simple contract with BayTech and enroll their employees in RITF Training Classes.

BayTech is a 501(c)(3) non-profit organization.

Standards of Standards

Transitioning into J-STD-001ES for Soldering

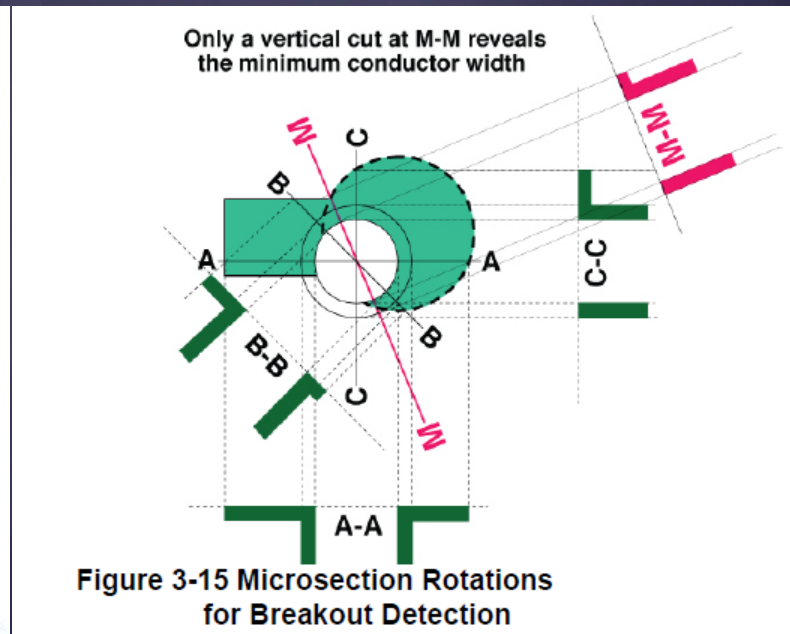
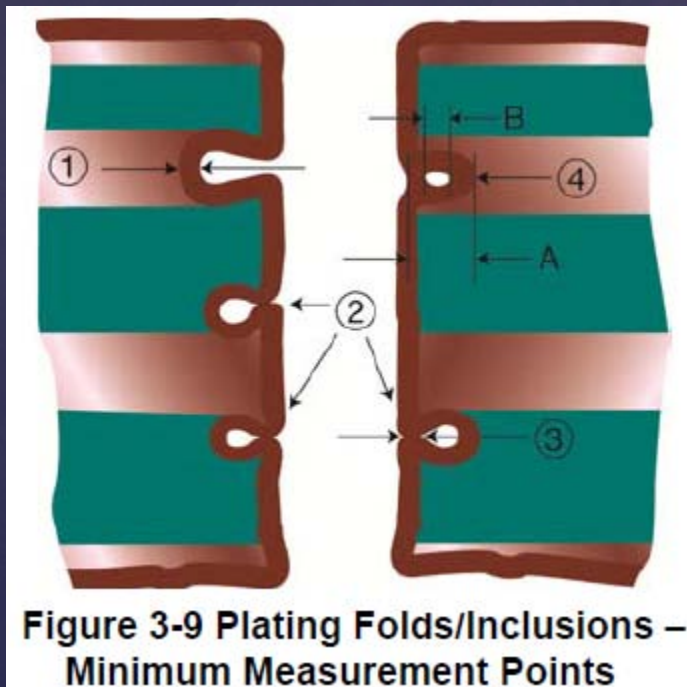
- Only IPC-certified Trainers allowed
- Class can be IPC standard course (either modular or non-modular) or “home-grown”
- Establishes NASA certification requirements still apply (NASA cert > IPC cert)
- Old Projects may allow J-STD-001ES certified operators or inspectors at any stage of production:
 - Manufacturing to drawing
 - Inspecting hardware
 - Modifying or repairing hardware



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Printed Circuit Boards



Source: Draft, IPC-6012D



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Printed Circuit Boards

- Printed Circuit Boards (PCBs) span across the EEE Parts and Workmanship disciplines
- Design and Quality standards used by NASA are generally IPC though not required at the Agency level.
- NEPP program supported improvements by adding a Space section to the rigid board standard, IPC-6012, circa 2006.
- Changes to IPC-STD-6012C in 2007 changed requirements in the Space section that may have reliability impact to NASA missions.
- Disconnect between requirement spec and delivery spec (want 6012B, get 6012C, mil-spec, ESA spec).
- High lot rejection rate (at GSFC). Is lot verification testing be performed? If so, why the delta?



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Printed Circuit Boards

- **Annular Ring (AR)**

- Ensures traces on layers (top, internal, bottom) connect electrically to entire barrel surface.
- Drill holes must be very precise with low AR to avoid reduced connection area or misaligned installed parts.

- **Etchback - Negative**

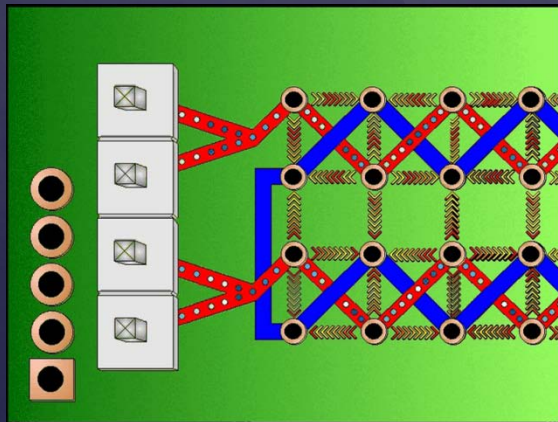
- Drilled hole walls must be cleared of resin smear and glass fibers with etchant followed by cleaning prior to plating
- Negative etchback over-etches the copper, recessing it from the wall inner diameter. Residues can be left in recess negatively affecting plating. Hole plating can fold over near recess trapping residue.
- Desired limit: No negative etchback; IPC-6012C 3/A allows 0.5 mil maximum
- Study of residue entrapment can show risk is acceptable. Interconnect Stress Test (IST) may also be a risk assessment test.

- **Etchback - Positive**

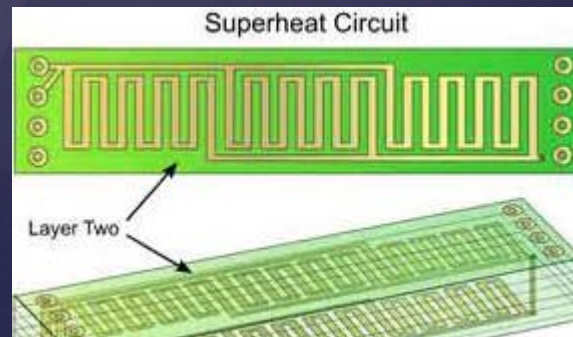
- Excessive positive etchback risks foil cracks developing after thermal stress
- Knowledge of dimension of positive etchback relative to trace geometry can reduce risk. Interconnect Stress Test (IST) may also be a risk assessment test.

Printed Circuit Boards

- Interconnect Stress Testing (IST)
 - An accelerated interconnect reliability assessment using a DC current to simulate thermal stressing (Hrs vs Weeks)
 - Gives more accurate failure analysis in pinpointing the site of the failure without further propagation
 - Requires special IST coupon – board house capability question
 - Technology owned solely by PWB company; IPC recently negotiated to buy equipment
 - IPC currently conducting validation testing for new IST Test Method to update TM-650 2.6.26

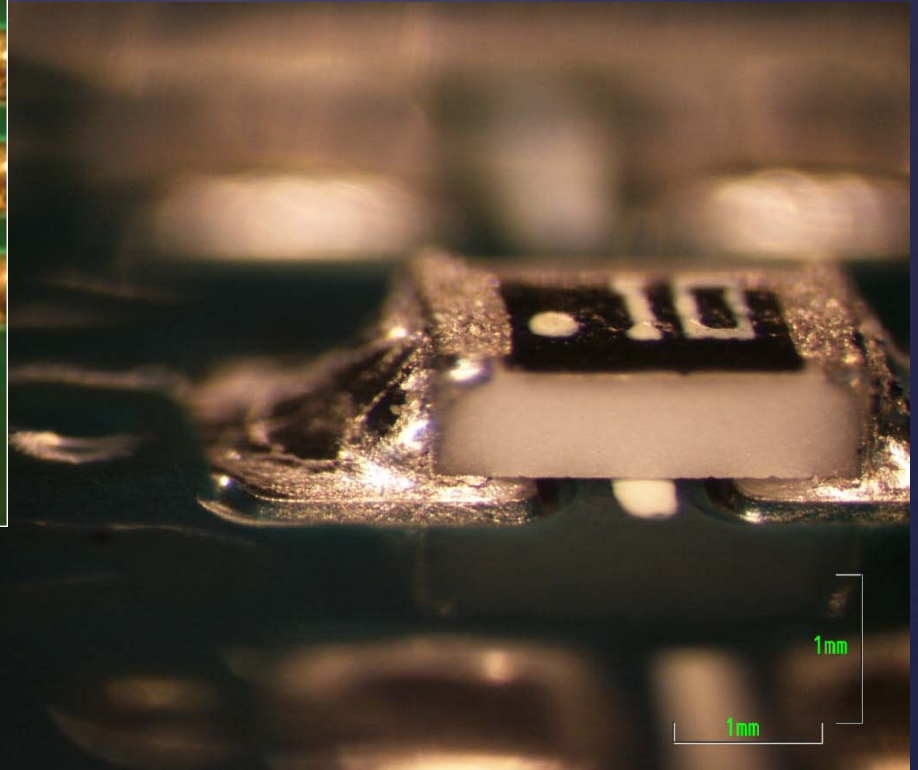
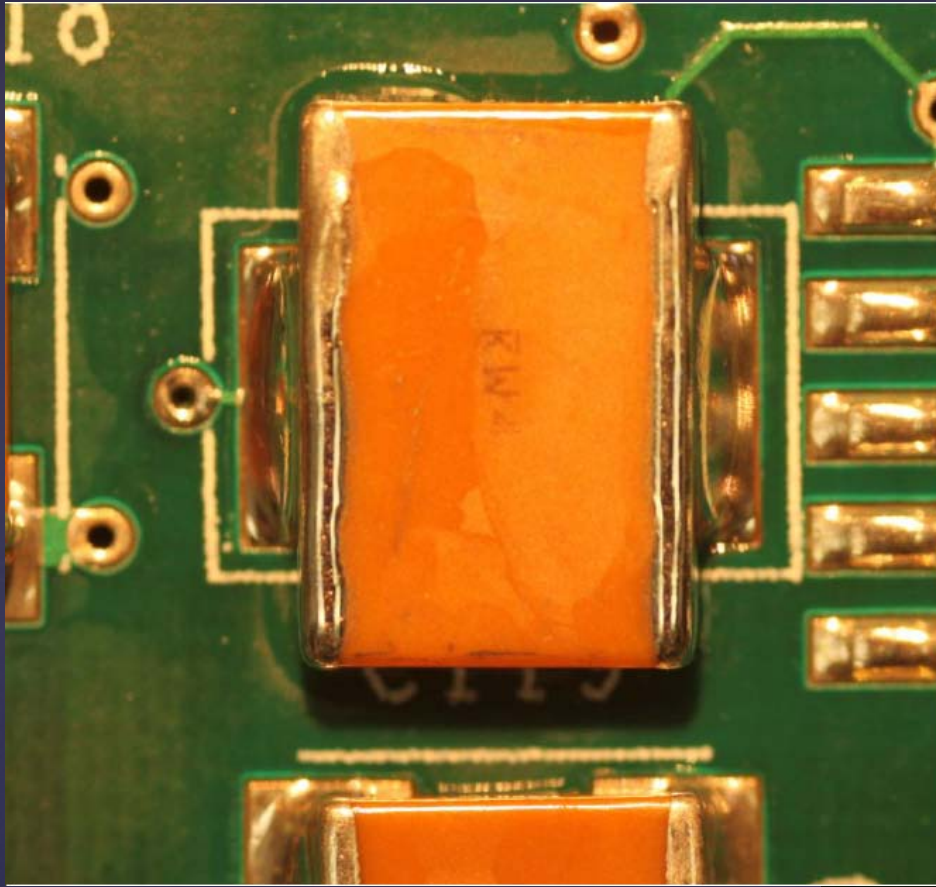


Source: PWB Corp.



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Soldering



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Soldering

- ❖ J-STD-001ES Adopted for all Programs and Projects October 2011.
- ❖ “New Items” analysis nearly finished to help suppliers update internal procedures to match from NASA-STD to J-STD-001ES.
- ❖ Important new areas:
 - Red Plague control for silver-plated wire
 - Time between <<dewpointing bake and soldering>> and then between <<soldering and cleaning>> is not limited to a maximum time.
 - Recognizes small fillet heights for smaller SMT packages (was 50%, now 25%)
 - Ball grid array and column grid array now standard interconnect types
 - Points to moisture control characterization methods used for plastic encapsulated microcircuits



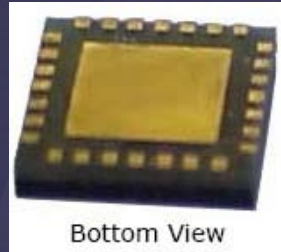
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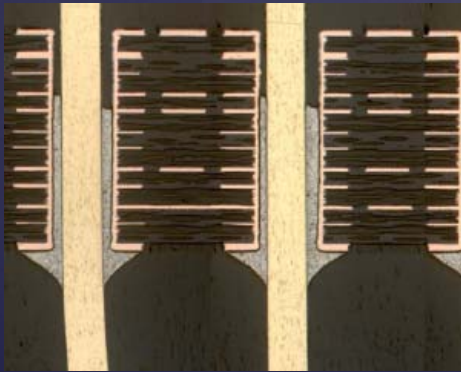
Soldering

Important new areas in J-STD001ES:

- Better traceability to IPC standards for flux, solder, paste
- Recognizes that cooling portion of soldering heat cycle must be controlled for ceramic capacitors



- Leadless Chip Carrier (LCC) and Land Grid Array (LGA) packages require customer approval to use.
- Dimension for LCC height off of the board is now subjective rather than dimensioned *"Parts shall be mounted with sufficient clearances between the body and the PCB to assure adequate cleaning and cleanliness testing"*
- LCC overhang allowed (25% max)
- Solder fill of through-hole joints: Minimum of 75% including end depressions, no void criteria
- Solder joints which are thermal connections require customer approved accept/reject criteria
- Ultrasonic cleaning OK with data



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Soldering

Important new areas in J-STD001ES:

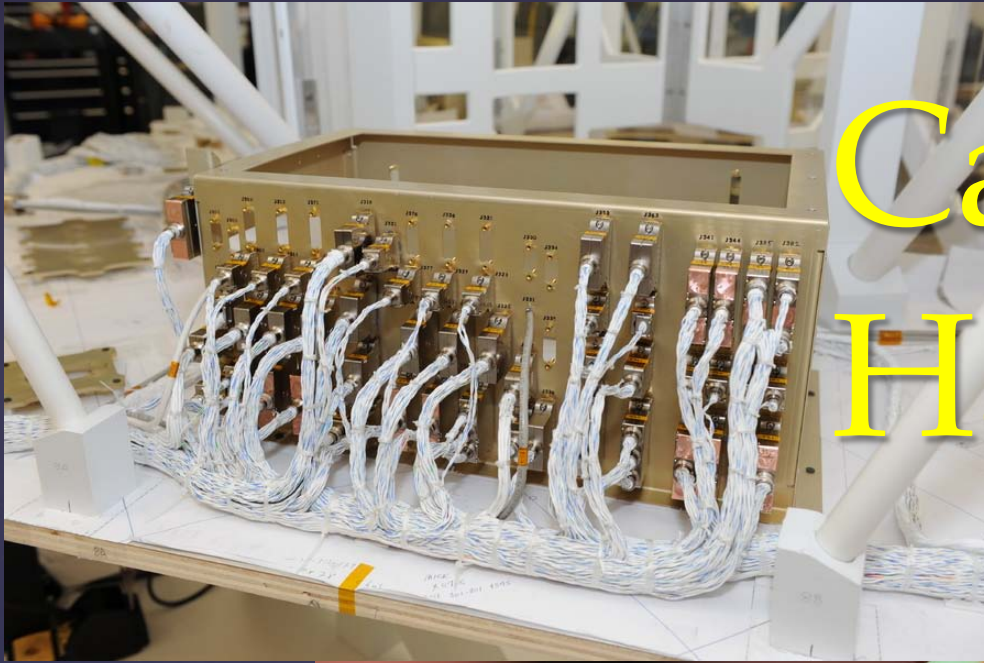
- Polymeric Applications Section: NASA will not use (see NPD 8730.5 and NASA-STD-8739.6)
- Requirements on PCB quality:
 - Emphasizes that some imperfections on boards “as received” are not defects
 - Names unacceptable defects caused by poor soldering
 - NASA re-engaging with IPC on IPC-A-600 series (6012, 6013, etc).
 - J-STD-001xS will have to keep pace to not contradict.
 - Assumption is that a “known good” board was used.



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Cables and Harnesses



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Cables and Harnesses

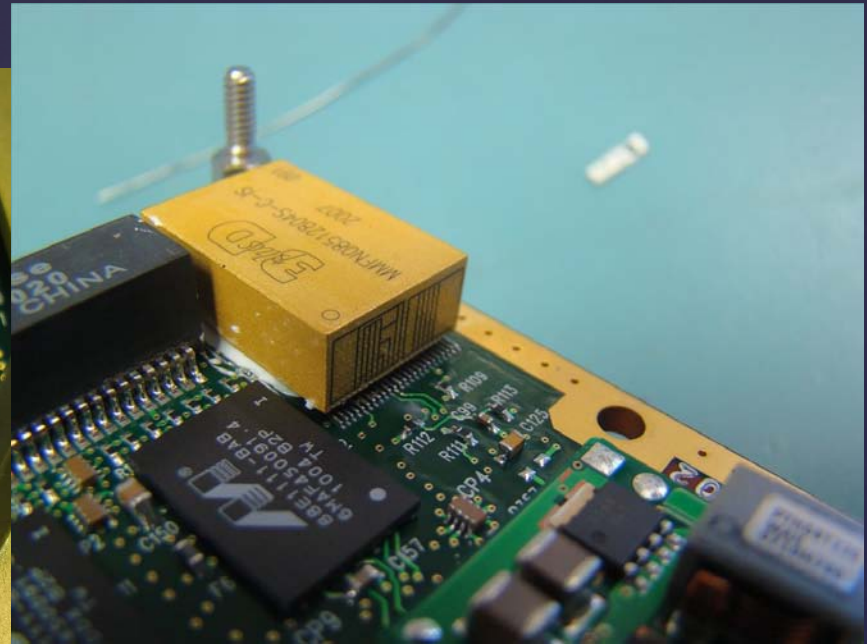
- ❖ IPC/WHMA-A-620AS published and meets or exceeds NASA-STD-8739.4 requirements.
- ❖ IPC/WHMA-A-620B published.
- ❖ Companion training not finalized.
- ❖ IPC tending toward two-week course to cover “base” document and then to teach the hands-on portion.
- ❖ This will be a significant impact to NASA supply chain though no alternative is defined.
 - Historically this has not been a hands-on class for IPC
 - Historically this has been a hands-on class for NASA
 - Base spec is very large. IPC wants to “touch” every requirement in base training
 - IPC testing hands-on class with experts. NASA lesson learned is that this class takes longer to teach to newbies so beta approach may not be valid.

NASA-STD-8739.4 due for revalidation in 2013. No major changes planned other than synchronization with 8739.6

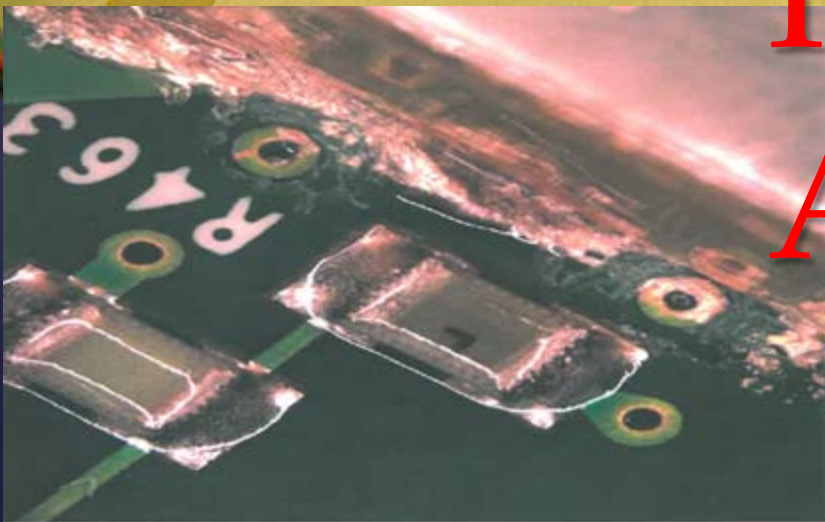


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Polymeric Applications



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NASA-STD-8739.1

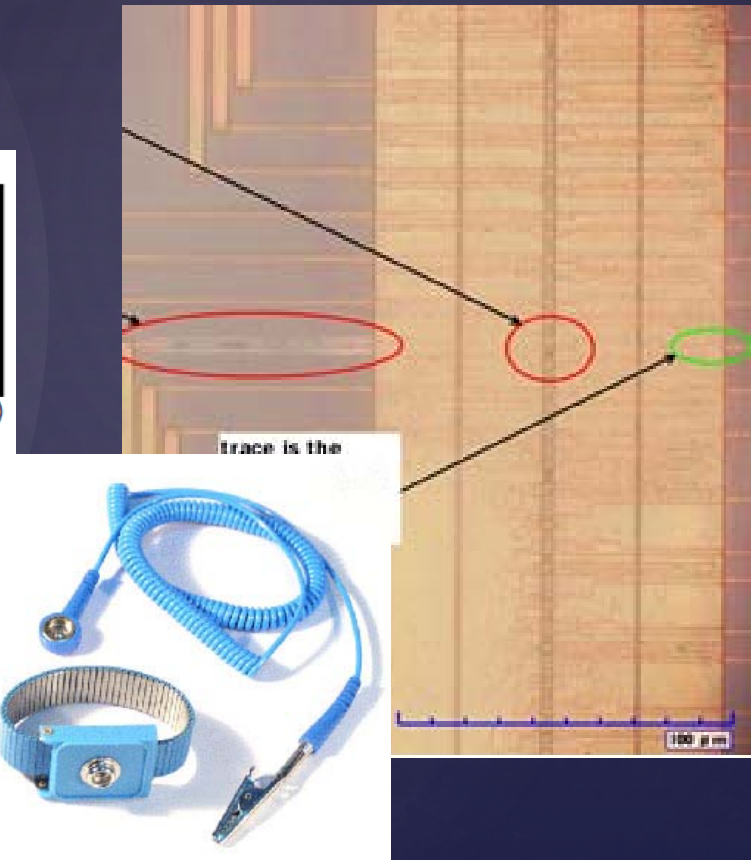
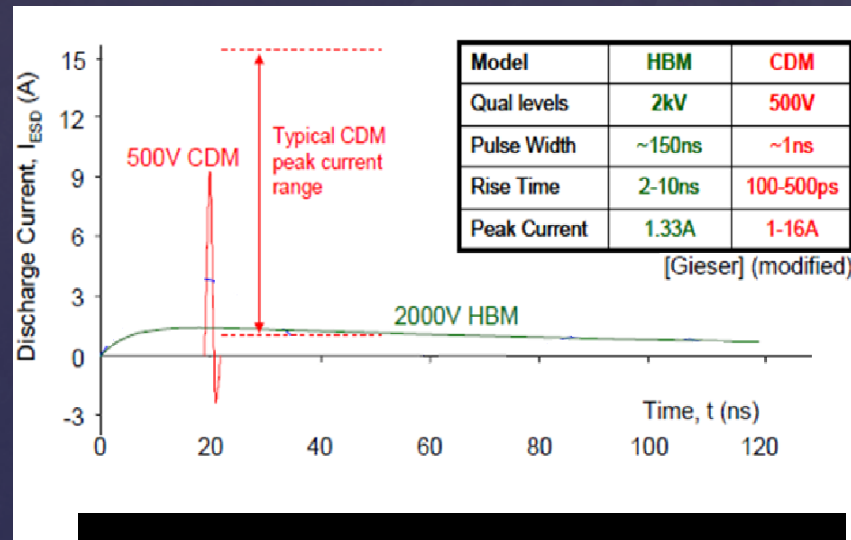
- ❖ Will be revalidated in 2013. Changes being considered:
- ❖ Remove “test specimen” requirement for all except conformal coating:
 - Requirement is confused with material qualification
 - Test method does not “test as you fly”. Uses a material qualification test method (*thus the confusion*)
 - Increased use of pre-mixed, frozen, small-portion staking material. Test sample size is much, much larger than amount used.
 - Some history with conformal coating that looks good initially and then degrades later



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ESD Control



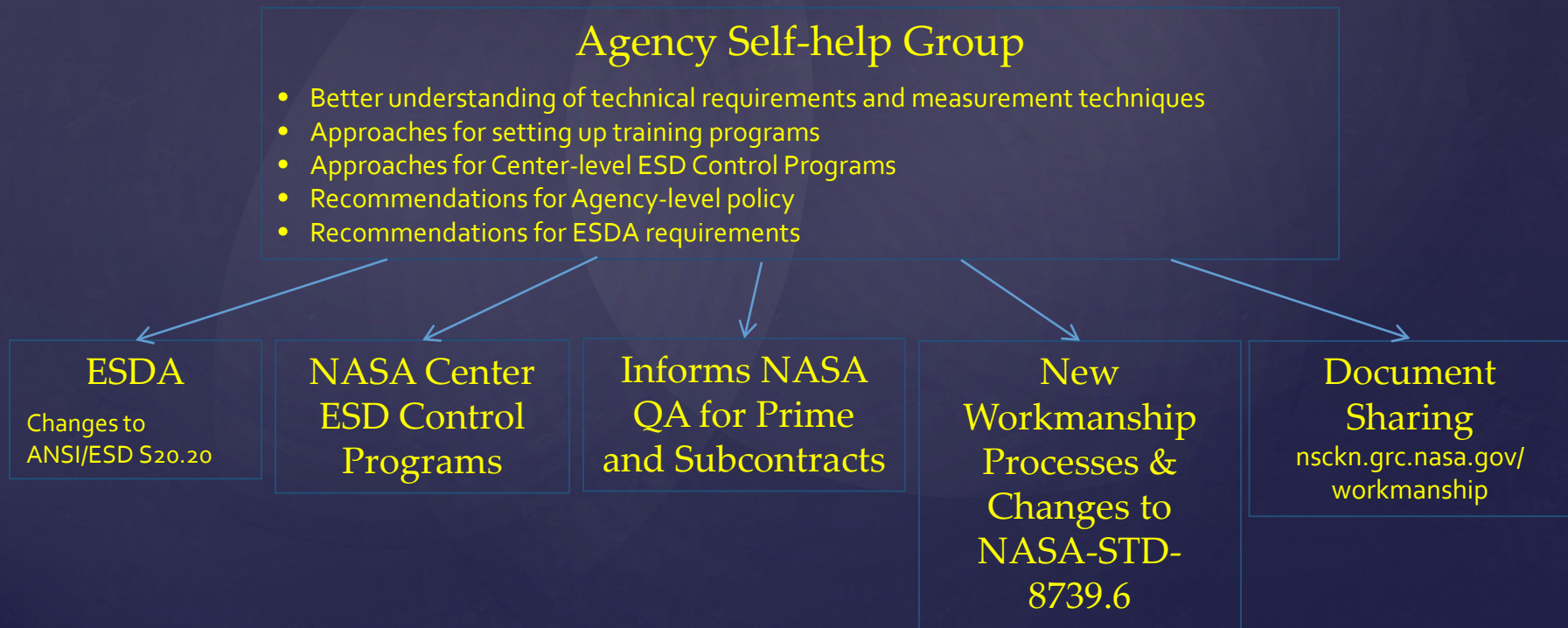
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ESD Control

Gene Monroe, LaRC:

- Hosting monthly Agency knowledge-sharing webex
- Acting as Agency representative at ESDA meetings



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ESDA

ANSI/ESD S20.20



ANSI/ESD S20.21

ANSI/ESD S20.20

Performance requirements:

example:

- Garment cuff-to-cuff resistance in Ω
- Dissipative resistance range in Ω
- Human Body Model event definition in V, A, μ Sec

Standard test methods

example:

- Garment qualification over temperature and humidity
- Floor resistance and grounding
- ESD chair qualification

ANSI/ESD S20.21

Assurance requirements:

example:

- Use of qualification tests vs verification tests
- Verification schedules
- Minimum data records
- Control processes in the case of failure, including root cause analysis
- When to stop work



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ESD Control

Example of ESD assurance requirement:

NASA-STD-8739.6, Paragraph 7.2.3:

“ESD wrist straps and heel strap systems shall be verified to be functional each time they are put on prior to entry into an Electrostatic Protected Area (EPA) or prior to coming within one meter of an ESD sensitive item (Requirement).”

- 2008: NASA Workmanship begins suggesting to the ESDA to have a Space-focused standard.
- September 2012: ESDA accepts NASA's formal proposal to make an Aerospace Standard that would include S20.20 requirements
- Over 20 aerospace organizations invited to participate
- Feedback indicates widespread grassroots support for approach
- February 2013: First face-to-face meeting at the ESDA Working Group meeting series (DoD participation limited by sequestration)
- Using NASA-HDBK-8739.21, Workmanship Manual for Electrostatic Discharge Control (Excluding Electrically Initiated Explosive Devices) as a guide for capturing all critical assurance requirements.
- Regular committee webex schedule being coordinated.



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Summary

New Workmanship Standard:

- VCS risk reduction
- Codifies training requirements
- Expands NASA Training Centers

Printed Circuit Boards:

- Workmanship adopting new discipline area.
- Particular concern around annular ring and etchback requirements.
- Opportunities in IST testing

Soldering:

- NASA will not use Polymeric Applications section.
- BGA and CGA interconnects now standard

Cable and Harness:

- IPC/WHMA-A-620AS.1 “meets or exceeds” NASA-STD-8739.4 on a requirements basis.
- Training program doubles in length.

Polymeric Applications:

- 5-yr review this year
- Seeking to modify test specimen requirement for staking, bonding.



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